Weather Note

AERIAL PHOTOGRAPHS OF A TORNADO PATH IN NEBRASKA, MAY 5, 1964

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During the afternoon and evening of May 5, 1964, a series of devastating tornadoes swept across eastern Nebraska. A portion of the damage path of one of the tornadoes was photographed the next day by Park Aerial Surveys, Inc., Louisville, Ky. This tornado, one of four that occurred during the afternnoon and evening in Nebraska, was in contact with the ground for approximately 70 mi. from 1800 until 2000 CST. Figure 1 shows the location of the damage reports listed in table 1.

Of the many personal accounts of the tornado, one is of particular interest because it applies to the area that was photographed. This description appeared in the May 6 issue of the *Omaha World Herald*. Tom Allan, a reporter for the newspaper, was driving west on highway Alt. 30–92 (fig. 1) when he approached a large thunderstorm a few miles west of Rising City. It appeared to be clearing to the south and the bulk of clouds was already north of the highway. Near the intersection where highway 81 branches north, halfway between Rising City and Shelby, he saw a strange cloud to the south that looked like a huge downpour of rain or hail about ½ mi. wide. In order to get a better look at the cloud, he pulled into a farm lane south of the highway. The cloud did not have the characteristic funnel shape; it was just a half-mile-wide mass of blue-black cloud touching the ground. As he backed out of the lane, he noticed debris blowing from the bottom of the cloud. The sky turned black before he could take a picture. Noticing its northeastward movement, he decided to drive west on highway Alt. 30–92. While he sped away, a glance in his rear view mirror revealed the headlights of two vehicles behind him. Suddenly they disappeared. His ears rang from an overpowering rumble, as a deluge of rain swept over him. As he reached Shelby the sky became light again and he turned around and headed back. Along the route he found a truck toppled on its side. The farm house into whose lane he had turned was flattened. Its occupants suffered minor injuries when the basement caved in on them. A little farther east another truck lay on its top.

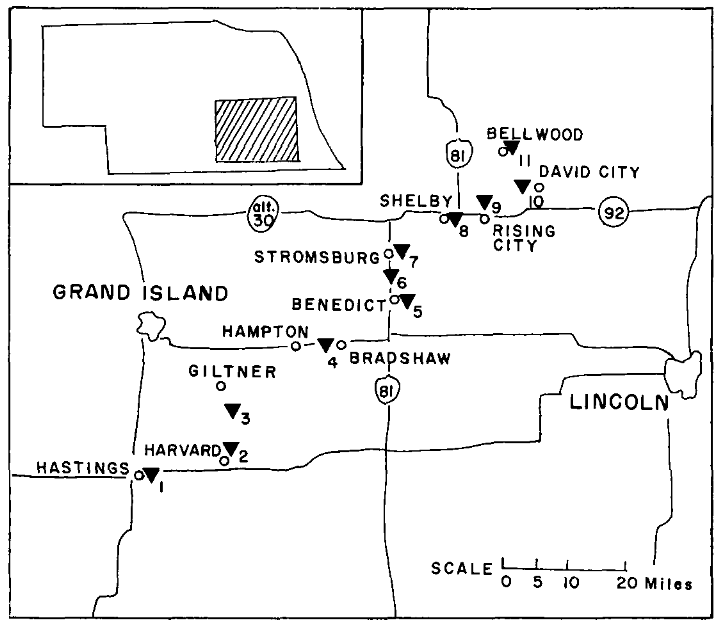


FIGURE 1.—Map of tornado area locating damage reports listed in table 1.

TABLE 1.—*Reports of damage by tornado in area of Nebraska shown in figure 1.*

No. (in fig. 1)	Location	Damage reported
1	Hastings	Minor injuries; rail cars derailed; extensive damage at municipal airport.
2	Harvard	20 injured (2 hospitalized); 1 power line down.
3	7 mi. north of Harvard	5 injured, 3 farms destroyed.
4	Area east of Hampton	14 farms destroyed, 11 damaged; 2 deaths.
5	Benedict area	4 farms damaged.
6	4 mi. south of Stromsburg.	2 injured.
7	Stromsburg area	2 injured; slight farm damage.
8	Shelby area	2 farms destroyed; 1 slight injury; 2 trucks damaged; moderate power line damage.
9	Rising City	4 farms destroyed.
10	1 mi. west of David City.	Minor injuries.
11	Bellwood and Butler County.	6 farms destroyed; 9 severely damaged; 90 power poles destroyed.

The events just described took place west of the intersection of highways 81 and Alt. 30–92 shown in figure 2. This is one of the series of aerial photographs made on May 6 from an altitude of 6,000 ft. by a mapping crew of Park Aerial Surveys, Inc. The photographs are remarkable in that they clearly show the path of the

FIGURE 2.—Section of tornado path west of intersection of highways 81 and Alt. 30–92. Vertical lines below the mosaic of figure 3 show location of this photo in total path. (Photo by Park Aerial Surveys, Inc., Louisville, Ky.)

tornado for approximately 8 mi. (fig. 3). The first truck found by Mr. Allan on his return is visible south of the road, lying on its side (arrow near left edge of fig. 2). It was west of the tornado path and therefore would have experienced a northerly wind, assuming counterclockwise rotation in the storm. The right edge of the surface marks, looking northeastward down the damage path, passed directly over the farm house where Mr. Allan had stopped to view the approaching storm. The marks define the axis of most intense destruction. It is interesting to note that three grain bins, not more than 100 ft. to the right of the path, were left standing. Grain bins as a rule are quite vulnerable to wind damage. There seems to be a sharp transition along the edges of the path from total destruction to little damage. Under magnification, the original pictures reveal a portion of a wall with a doorway in the field across the road from the farmstead to the northeast. Seven farmsteads were on or very near this segment of the damage path. Four of these have debris patterns evidencing rotation; i.e., debris down the path on the right and up the path on the left. The other three apparently have debris scattered down the path only. The marks show definite cyclonic curvature. However, in many cases the curvature is so slight that, if visible at all when viewed from the ground, it appears as no curvature at all.

In view of this, it is quite possible that many cases of damage, classified as the result of straight line winds, may actually be tornado damage paths. Van Tassel [1] reported marks visible from aerial photographs of a cultivated field following the passage of a tornado. These marks were only barely noticeable from the ground. Upon closer inspection, they appeared as ridges or dikes $\frac{1}{4}$ to $\frac{1}{2}$ in. in height. These marks on the aerial photographs are probably the result of light being reflected differently from the disturbed areas than from the undisturbed areas. The original pictures when viewed under strong magnification show the marks to be areas where all vegetation was removed leaving the soil bare.

A damage survey by R. E. Myers, State Climatologist for Nebraska, revealed that the path was easily followed over its entire length. Mr. Myers stated that the path gave the impression that an enormous vacuum cleaner had swept the ground clean of vegetation, loose soil, and all other movable objects. Hall and Brewer [2] reported on a tornado damage path through a forest region. From the data available, they constructed hypothetical models of wind distributions. These models consisted of combinations of rotation, translation, and sink. Certain portions of this damage path seem to fit their models. These authors also noted the sharp demarcation between damage and no damage along the edges of the path. The damage path seems to evidence rotation as well as translation of the storm. The surface marks define the axis of maximum wind; i.e., the resultant of rotation and translation on the right side looking down the path. Careful examination of the photos (fig. 4) shows that the

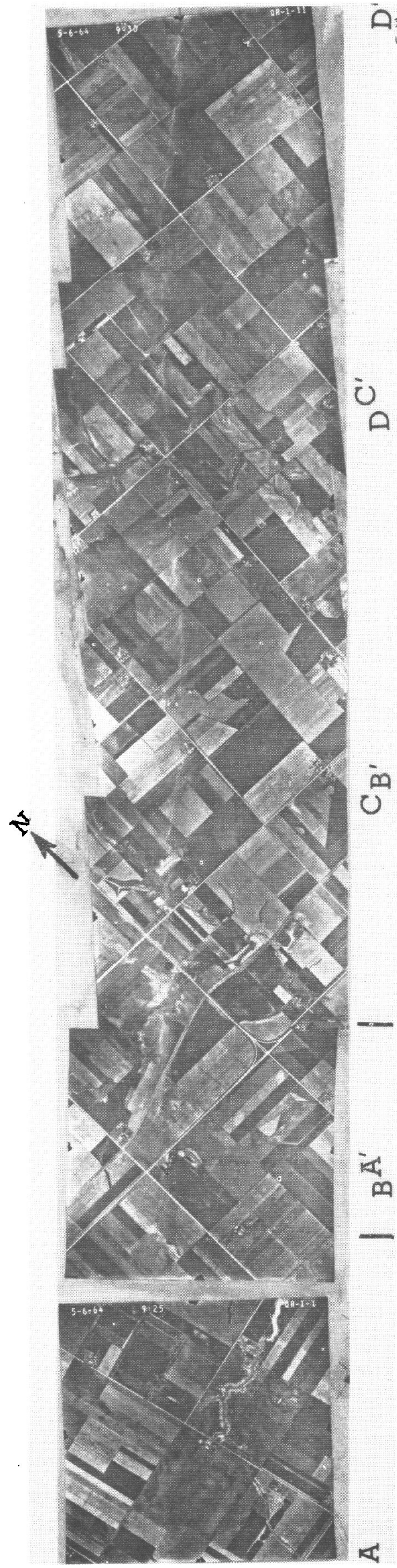
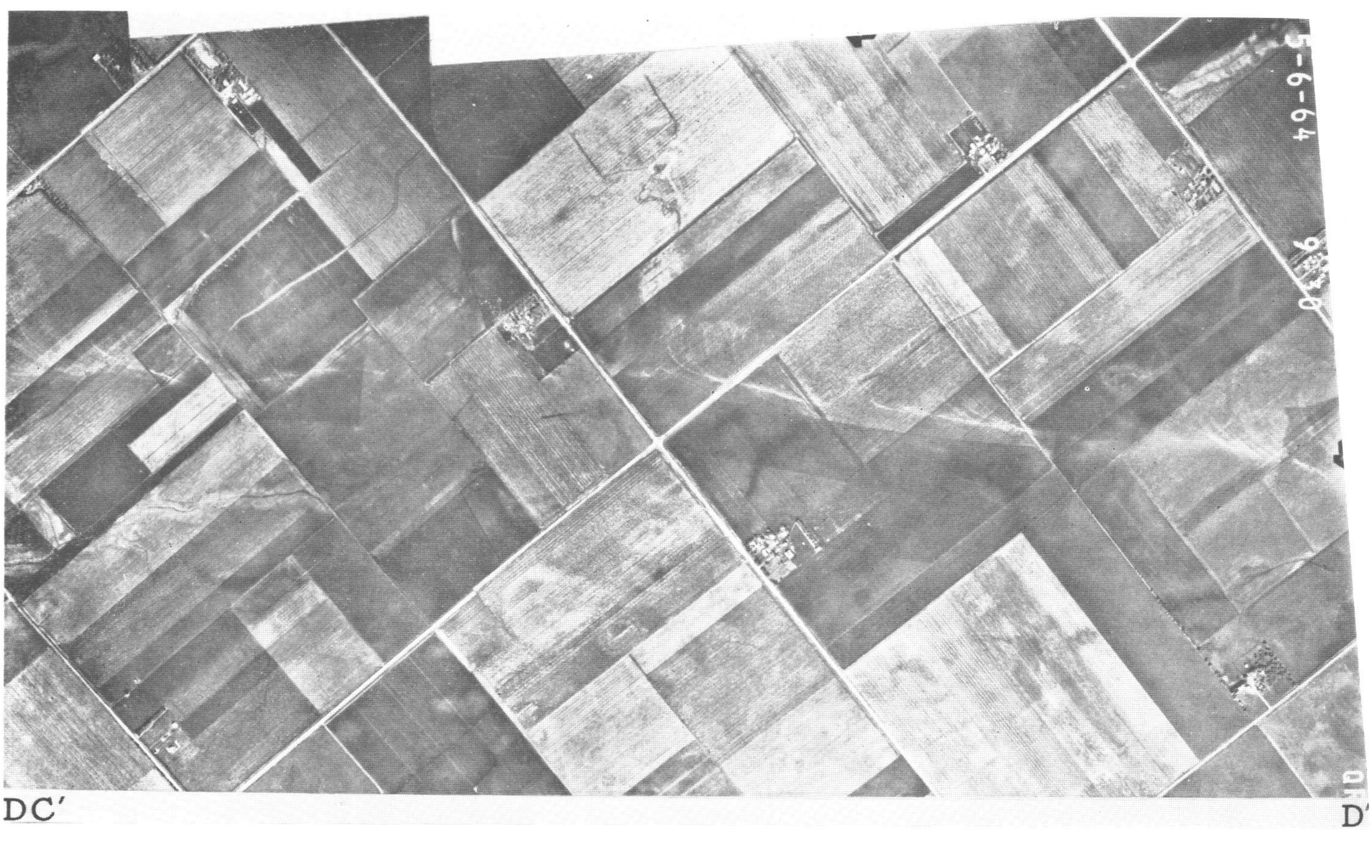


FIGURE 3.—Mosaic of tornado path over a length of 8 mi. Vertical lines show location of figure 2. Letters show locations of similarly identified sections shown in larger scale on the following pages; A and A′ indicate the left and right edges, respectively, of the first section. (Photographs and mosaic made by Park Aerial Surveys, Inc., Louisville, Ky.)

FIGURE 4.—Mosaic of figure 3 cut into sections to allow larger-scale reproduction. Placement of identifying letters shows overlap between adjoining sections.

CB' DC'



DC' D'

marks define closed loops at several points. Some of these loops have a larger radius of curvature than do others, suggesting perhaps that the diameter of the vortex was oscillating about a mean.

ACKNOWLEDGMENTS

The author wishes to thank W. Sidney Park for his permission to use his remarkable photographs and for preparing the mosaic; R. E. Myers for his damage survey; Tom Allan for his personal account of the storm; and O. K. Anderson, MIC, WBAS, Louisville, Ky., for bringing these pictures to the attention of the Severe Local Storms Forecast Center. Thanks are also due D. C. House and J. G. Galway for their assistance in preparing this note.

REFERENCES

1. E. L. Van Tassel, "The North Platte Valley Tornado Outbreak of June 27, 1955," *Monthly Weather Review*, vol. 83, No. 11, Nov. 1955, pp. 255–264.
2. F. Hall and R. D. Brewer, "A Sequence of Tornado Damage Patterns," *Monthly Weather Review*, vol. 87, No. 6, June 1959, pp. 207–216.

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CORRESPONDENCE

Comments On "A Synthesis of Interpretations of Extratropical Vortex Patterns As Seen by TIROS"

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Dr. Widger [1] has performed a valuable service by summarizing many papers that have treated the interpretation of satellite pictures. His list of 28 references is proof enough that this synthesis is needed by meteorologists who do not have the time or the need to study each paper individually. Two points in his summary, it seems to me, should be discussed.

Perhaps the most important is the dispersion of pictured cloud spiral centers about the atmospheric circulation center. Questions important to the meteorologists are: (a) Is the apparent dispersion the result of inaccurate determination of the satellite picture location or displacement of the analyzed low pressure center? (b) Is the dispersion the result of cloud patterns being embedded in atmospheric layers other than the surface or the 500-mb. levels in strongly sloping cyclones (see [1] fig. 13)? (c) Can the cloud spiral centers actually be significantly displaced from the circulation centers? The picture interpretation will differ markedly, depending upon the true state of affairs regarding questions a, b, and c.

There can be little doubt that *some* of the dispersion of cloud vortex centers about the low pressure center is due to inaccurate location of both picture and cyclonic circulation (e.g., see [2]). A hint of this conclusion is obtained by separating the dispersion statistics into two groups; one, those cases of spirals over land where the standard data are dense, and two, those over ocean areas where the data are more widely separated. The former group exhibits less scatter. But the whole matter cannot be so simply explained.

Neither can the scatter of points in Widger's figure 13 a and b all be explained by the alternative that invokes the sloping axis of cold Lows. Although the height of the pictured clouds is frequently unknown, there is good evidence that many of these patterns lie *somewhere* between the surface and 500 mb. If sloping axes are the reason for displacement of the positions, it follows that the center of the pictured spiral pattern should lie on a straight line between the surface and 500-mb. Low positions. Many do not. Analysis of Widger's figure 13 shows that many of the cases shown there cannot be so positioned.

We are led to the conclusion that it is possible for spiral cloud patterns to exist when there is no actual closed vortex in the air flow. Indeed, an excellent example of this is described in his reference 9.

Widger [1] concludes on page 272 that, "Since a clearly definitive cloud vortex seems to require the existence of an upper-air circulation, better correspondence between the cloud vortex and upper-air vortex or trough . . . seems reasonable. . . ." This statement does not appear justified insofar as it seems to conclude an "upper-air-vortex" is required to produce a cloud spiral pattern.

The mechanisms that could produce such a pattern are several. The one discussed in reference 9 involves orientation of cloud bands along the vertical shear vector, thus along the thermal wind rather than the actual wind. Another mechanism involves lateral shear, but nothing